An epidemiological investigation of COVID-19 outbreaks in a group of care homes in Wales, UK: a retrospective cohort study

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ABSTRACT

Background This study describes the epidemiology of COVID-19 outbreaks in four care homes in terms of spread, severity, presentation and interventions.

Methods Participants were 100 residents and 102 staff from four co-located care homes in Wales. Data were collected from the homes and Public Health Wales, including demographics, presentations, test status and results, hospital admissions and deaths. Genomic sequencing of confirmed case samples was completed, where possible. Epi-curves, crude attack rates, a Kaplan-Meier survival curve and adjusted hazard ratios were calculated using R.

Results About 14 confirmed and 43 possible resident cases, 23 confirmed and 47 possible staff cases occurred. Crude attack rates of possible and confirmed cases were 57% (residents) and 69% (staff). Genomic sequencing for 10 confirmed case PCR samples identified at least 5 different UK lineages of COVID-19.42 (42%) residents died, 23 (55%) with COVID-19 or suspected COVID-19 recorded on the death certificate. The hazard ratio for death amongst resident possible and confirmed cases compared to null cases, adjusting for age and sex, was 13.26 (95% CI 5.61–31.34).

Conclusions There were extensive outbreaks of COVID-19 in these homes with high crude attack rates and deaths. Universal testing and early isolation of residents are recommended.

Keywords communicable diseases, epidemiology, older people

Introduction

Background

Care homes provide accommodation to individuals needing significant help with personal care,[1] with approximately 416 000 people living in care homes in the UK.[2] Care home residents live in close proximity to each other, which along with the typical older ages and common chronic underlying conditions of residents, means these facilities are at high risk for severe outbreaks of COVID-19.[3,4]

The pandemic has disproportionately impacted care home residents globally, with 19–72% of total COVID-19 deaths being reported in these settings.[5] Care homes in Wales have become hotspots for outbreaks, with significantly increased risks of death amongst residents compared to previous years.[6]

Once outbreaks occur in care homes they can spread rapidly through the resident population and staff,[4,7,8] leading to high mortality.[7,9,10,11,12]

A particular challenge is transmission by asymptomatic individuals, who may or may not go on to be symptomatic.[7,9,10,11,12,13] Ladhani et al.[14] found that 43.8% of confirmed resident cases and 49.1% of confirmed staff cases were asymptomatic.

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It is important to have more studies in UK settings, featuring both residents and staff and covering the full timeframe of an outbreak, to further understanding of COVID-19 outbreaks in care homes. Limited data are available on staff demographics and presentation, an understanding of which may assist in identification of possible cases for testing. The care homes involved in this study approached Public Health Wales to assist in an epidemiological investigation following high numbers of confirmed cases of COVID-19 and deaths. This study set out to describe the epidemiology of these outbreaks in terms of spread, severity, presenting symptoms and interventions implemented to reduce spread.

Methods

This was a retrospective cohort study, consisting of data for all staff and residents in four co-located care homes (Home A, Home B, Home C and Home D) between February and May 2020. Note that Home D is situated within Home C as a separate sealed-off unit.

The study time-frame covered 18 weeks, from 2 weeks prior to symptom onset in the first possible case in the homes (ensuring coverage of incubation periods) until 2 weeks after symptom onset in the final confirmed case.

Participant eligibility criteria:

- Any resident living in one of the homes at any time during the study time-frame.
- Any staff member working in one of the homes at any time during the study time-frame.

Definitions used within the study are as follows:

Possible case: any staff member or resident without a positive viral throat swab test, with onset of new symptoms (fever, cough, shortness of breath or anosmia) within the study time-frame.

Confirmed case: any resident or staff member with a positive viral throat swab test.

Null case: Any resident or staff member not meeting the possible or confirmed case definitions.

Symptom onset date: Date of onset was taken as the earliest date of new symptom onset. Asymptomatic confirmed cases were excluded from epi-curve and cumulative incidence graphs, as it was not possible to determine true onset date.

Data were collected from the Care Home managers, Public Health Wales and the local health board, and included the following:

- ***Test data:*** Prior to May 2020, testing was triggered for those who were symptomatic with symptoms of a cough, fever, shortness of breath or anosmia. From May, all staff and residents were tested as part of regular screening. Staff and residents were tested with viral throat swabs, which were analyzed at the University Hospital of Wales' virology laboratory for Coronavirus SARS-CoV-2 RNA, by PCR with a test considered positive if Coronavirus SARS-CoV-2 RNA was found to be present.
- ***Care home data:***
  - Resident and staff demographics: counts, gender and age (age of residents was taken as their age on 1 April 2020).
  - Presenting symptoms and onset dates, as recorded by the care home managers in their line lists. Residents were monitored daily for symptoms.
  - Location of confirmed and possible resident cases within each home.
  - Hospital admissions: Dates and reasons of hospital admissions were obtained from care home managers and local health board data via Clinical Portal.
  - Deaths: Dates and causes of death, based on death certificate recordings.
  - Staff areas of work: Individuals identified as working in more than one of the study homes were assigned to both for the purpose of descriptive analysis on that particular home, but were not double counted for analysis involving all homes.
  - Onset dates of COVID-19 response interventions: enhanced cleaning, personal protective equipment use and training, isolation of residents, restrictions on shared space and visiting cessation.
- ***Genomic data:*** Genomic sequencing data from available throat swab samples were obtained from Public Health Wales Microbiology department and the Pathogen Genomics Unit (PenGU).

  Samples were reverse-transcribed and then amplified using the ARTIC v3 primers and protocol.[15] Resulting amplicons were prepared for sequencing using Illumina Nextera XT library preparation kit and sequencing was performed on the Illumina NextSeq using the NextSeq Mid-output v2.5 sequencing kit (300 cycles).

  For each sample, all sequences were quality trimmed (Trim-Galore v0.6.5) and then aligned to the SARS-CoV-2 reference sequence (MN908947.3) using bwa v0.7.17. Once aligned, primer sequences were coordinate-trimmed and consensus fasta sequences generated using iVar (v1.2.2). This process is provided as a Nextflow workflow (https://github.com/connor-lab/ncov2019-artic-nf). Consensus fasta sequences were submitted to the COVID-19 Genomics UK Consortium (COG-UK) analysis environment hosted on MRC CLIMB, and each sequence was assigned a global lineage.[16] Alongside this, to facilitate analyses of local outbreaks, a more granular 'UK lineage'

Table 1 Counts and percentages of resident and staff populations at risk, possible cases, confirmed cases and crude attack rates, by home and as a total

Home	Residents				Staff			
	n	Possible cases[a]	Confirmed cases[a]	Crude attack rate[b]	*n*	Possible cases[c]	Confirmed cases[c]	Crude attack rate[d]
A	33	11 (33%)	2 (6%)	39%	36	9 (25%)	3 (8%)	33%
B	34	18 (53%)	6 (18%)	71%	30	13 (43%)	16 (53%)	97%
C	26	11 (42%)	5 (19%)	62%	27	16 (59%)	4 (15%)	74%
D	7	3 (43%)	1 (14%)	57%	13	12 (92%)	1 (8%)	100%
Total	100	43 (43%)	14 (14%)	57%	102[e]	47[e] (46%)	23[e] (23%)	69%

[a]Percentage is of resident *n*.

[b]Possible and confirmed resident cases combined.

[c]Percentage is of staff *n*.

[d]Possible and confirmed staff cases combined.

[e]Some staff members worked in both Home C and Home D, so they have not been counted twice for the total staff value.

and 'phylotype' were assigned to each sample using a bespoke phylogenetic analysis pipeline (https://github.com/COG-UK/grapevine/).

Data analysis

Data were analyzed in R using tidyverse packages, including ggplot2,[17,18,19] to summarize demographic data, produce epidemic-curves, calculate hazard ratios (adjusted for age and sex) for death amongst possible and confirmed resident cases compared to null resident cases, and to generate a Kaplan-Meier survival curve. We calculated crude attack rates as the total confirmed and possible cases divided by the relevant population at risk.

Results

Population at risk

The study included 100 residents (41% male and 59% female, age range 66–100 years, mean age 82.4 years) and 102 staff members (7% male and 93% female, age range 16–69 years, mean age 41 years) (Table 1). During the study time-frame 70 (69%) staff and 57 (57%) residents presented with a new symptom.

Testing coverage and results

Testing for COVID-19 occurred for 57 (57%) of residents and 75 (74%) of staff. There were 42 individuals (26 residents and 16 staff) presenting with a typical COVID-19 symptom who were not tested.

Of the 132 individuals with sample results, 46 had both recorded onset dates of symptoms and recorded sample dates. For these, there was a mean time of 20 days from symptom onset date to test date, with a range of −5 to 65 days.

There were 14 (14%) confirmed cases amongst the resident population and 23 (23%) amongst the staff population. Of the 14 residents testing positive, 8 (57%) were male and 6 (43%) were female, with an age range of 66–99 years and a mean age of 79.4 years. Of the 23 staff members testing positive, 2 (9%) were male and 21 (91%) were female, with an age range of 19–69 years and a mean age of 42.3 years.

Crude attack rates

The crude attack rates were 69% amongst staff and 57% amongst residents across the combined homes. Table 1 includes a breakdown of the crude attack rates amongst staff and residents for each home.

Presenting symptoms

Recorded presenting symptoms amongst possible and confirmed cases are shown in Figure 1. At least one typical COVID-19 symptom (cough, fever, shortness of breath or anosmia) was recorded in 19 (82%) of the 23 confirmed staff cases and 10 (71%) of the 14 confirmed resident cases.

Spread of COVID-19 in the homes

Epidemic curves of all possible and confirmed cases amongst residents and staff by date of onset of initial symptoms for each home are presented in Figure 2.

Home A appears to have an initial point source pattern with a single peak in cases on the 13 March 2020, followed by an intermittent source pattern from then until the last confirmed case.

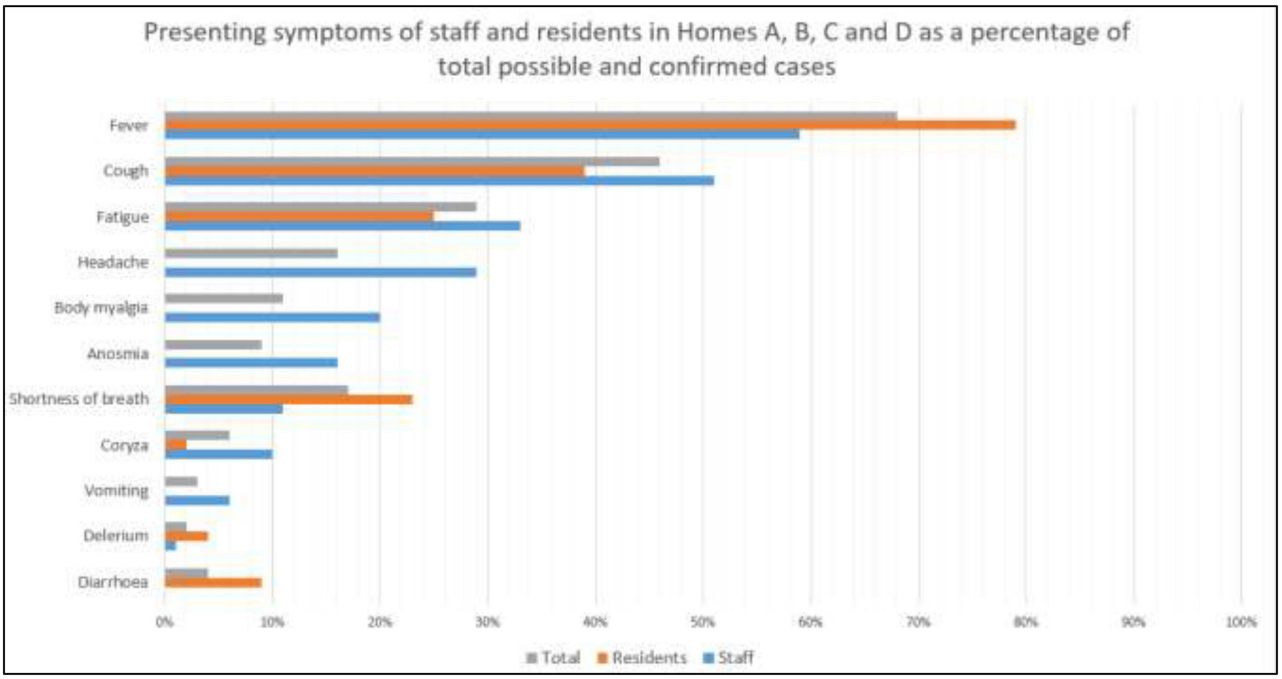

Fig. 1 Horizontal bar chart of presenting symptoms of staff and residents in Homes A, B, C and D, as a percentage of total possible and confirmed cases.

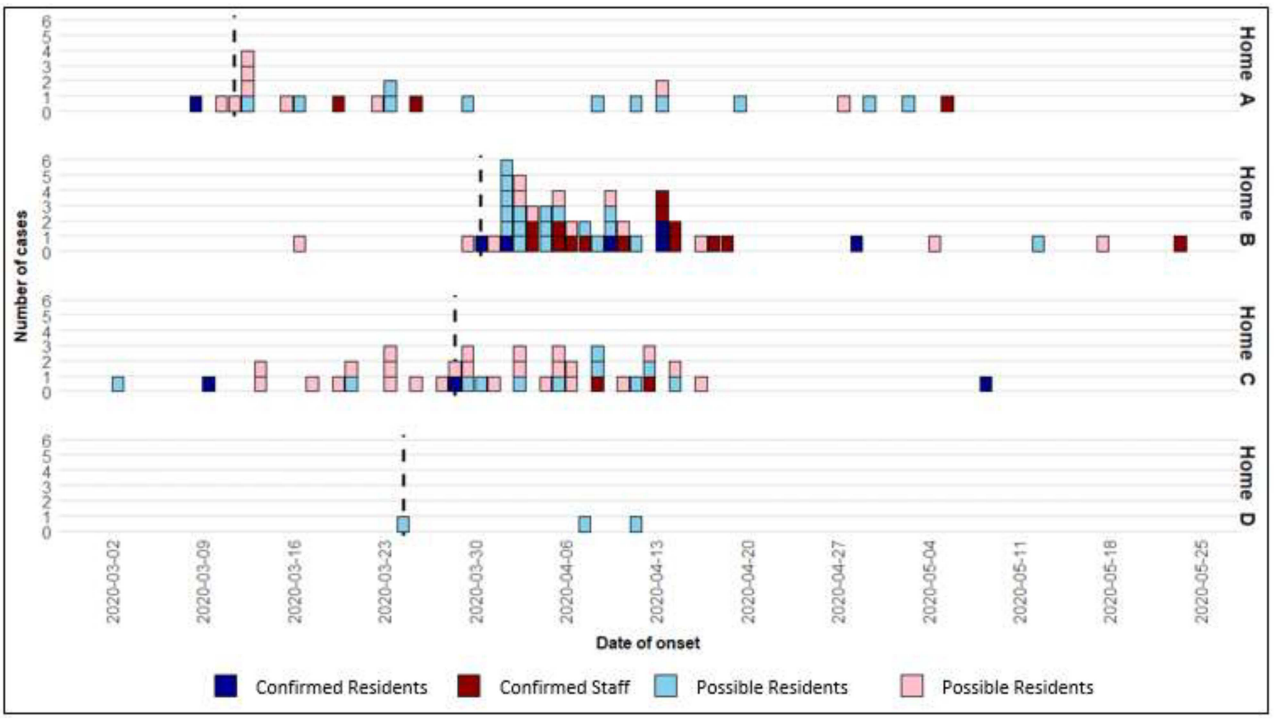

Fig. 2 Epi-curves of all possible and confirmed cases amongst residents and staff by date of onset of initial symptoms in Home A (*n* = 24), Home B (*n* = 51), Home C (*n* = 32) and Home D (*n* = 16). Dashed black line indicates date from which residents were isolated. Note—8 confirmed cases had no date of onset and were therefore not included in the epi-curves.

Home B had a couple of isolated cases in March before a sharp rise and peak at the end of March, peaking on the 2 April 2020 when there was an onset of 6 new suspected or confirmed cases in a single day. A continuous source pattern is then seen, suggesting person-to-person spread over the next 2–3 weeks.

Homes C and D have a propagated pattern of transmission with small intervals between small peaks.

Spot maps of possible and confirmed resident cases within each home did not appear to show any spatial clustering over time, with cases being spread throughout the homes rather than localized to specific floors, wings or areas.

Genomic sequencing

Identifiable lineages via genomic sequencing were obtainable from 10 PCR samples (27% of confirmed cases) taken amongst staff and residents at the homes (2 from residents and 8 from staff), with five different COVID-19 lineages identified.

Severity of COVID-19 in the homes

Hospital admissions were required for 4 residents, 3 of which were confirmed cases (21% of confirmed resident cases), and 4 staff members, who were all confirmed cases (17% of all confirmed staff cases).

There were 42 resident deaths across the 4 homes; 42% of the total resident population at risk, based on all-cause mortality. Of these, 91% died in the homes, and 9% died in hospital. In April, 30 residents died; more than twice the number of deaths in a single month than in any other month in the preceding 27 months, and six times higher than the monthly average for January 2018 to March 2020.

Home A had the lowest all-cause case fatality proportion at 27% (N = 33), Home B had the highest case fatality proportion at 56% (N = 34), whilst for Home C it was 42% (N = 26) and in Home D it was 43% (N = 7). There were no deaths amongst staff members.

Of the 42 resident deaths, 4 (10%) had COVID-19 recorded as the cause of death, 19 (45%) had suspected COVID-19 as the cause of death and 19 (45%) had other causes of death recorded. Therefore, 23 (55%) of the deaths during the study timeframe were given COVID-19 or suspected COVID-19 as cause of death on the death certificates. Of the 42 deaths, 30 (71%) displayed symptoms of COVID-19 prior to death.

Based on all-cause mortality, 29% of the confirmed and 61% of the possible resident cases died, compared to 28% of the null resident cases. Time to event analysis found a hazard ratio of 13.26 (95% CI 5.61–31.34) for being a possible or confirmed case amongst residents, after adjusting for age and sex. No significant differences in mortality were found between male and female residents, or between those aged under 80 and 80 plus.

A Kaplan-Meier survival curve (Fig. 3), for all-cause mortality amongst the resident population, shows a sharp drop in survival probability between approximately 30 days and 65 days after the start of the study time-frame, at the peaks of the outbreaks. The probability of survival at 30 days from the start of the study period was 96% (95% CI 92–100%), whereas at day 65 the probability of survival had reduced to 62% (95% CI 53–72%). Survival probability plateaued after day 73 at 58% (95% CI 49–69%), after which no further deaths occurred during the study period.

COVID-19 interventions

All staff members testing positive stopped working with immediate effect and isolated for 2 weeks. All residents returning to a home from hospital were isolated in their rooms for 2 weeks.

Interventions included:

- Cessation of visiting: implemented from the 12 March 2020 at all homes.
- Isolation of all residents: Implemented first by Home A (12/03/2020), followed by Home D (25/03/2020), Home C (29/03/2020) and Home B (31/03/2020).
- PPE use: Implemented first by Home A (12/03/2020), then Homes B and D (25/03/2020) and Home C (29/03/2020).

Discussion

Main finding of this study

COVID-19 spread rapidly amongst staff and residents in the care homes following multiple introductions and likely subsequent person-to-person spread.

What is already known?

The significant outbreaks of COVID-19 observed at the four homes are in line with outbreaks observed in other epidemiological studies in the USA and UK.[4,7,8,9,10,11,12,13,20]

Genomic sequencing of viable samples showed that there were at least five different UK lineages of COVID-19 present in the homes, demonstrating multiple introductions of COVID-19 to the homes, which has also been observed elsewhere.[9,20] However, limited conclusions can be drawn here due to the small number of sequenced samples.

Amongst confirmed cases of COVID-19 the most common presenting symptoms were fever and cough, which is in keeping with the general accepted primary symptoms of COVID-19.[23] Anosmia was not reported as a symptom amongst any confirmed resident cases, which echoes the findings of other studies.[7,9,11,12] This could be due to anosmia being a difficult symptom for residents with cognitive or communication problems to express.

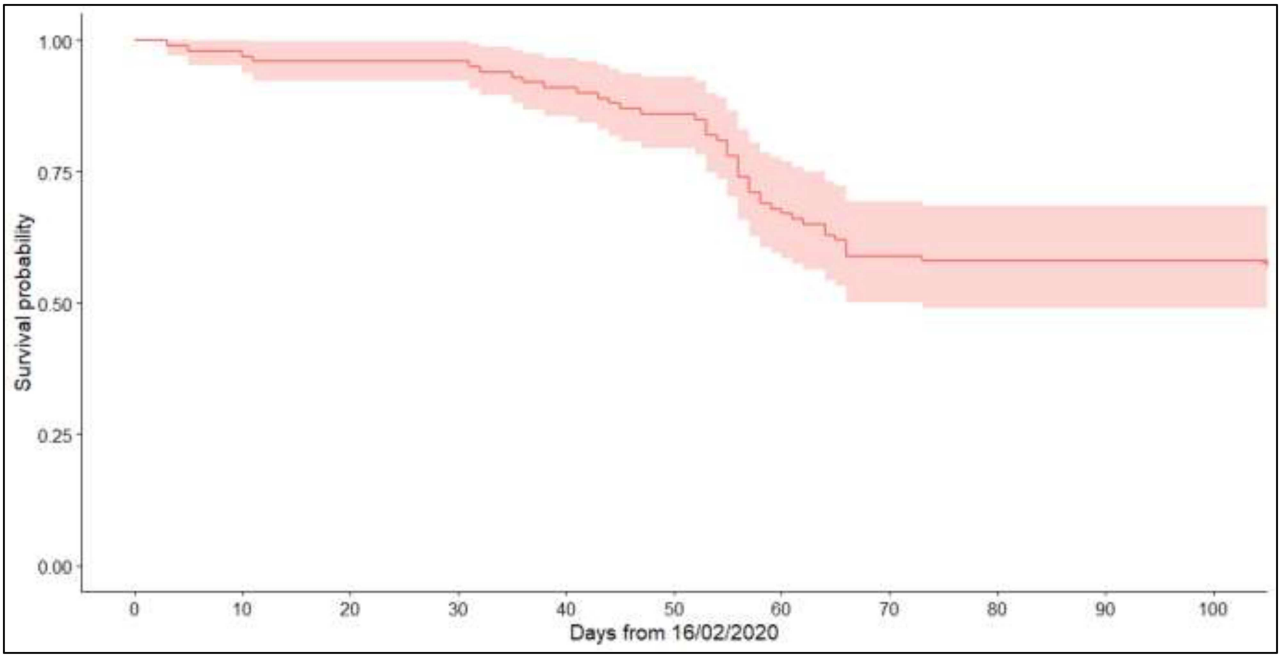

Fig. 3 Kaplan-Meier survival curve illustrating resident survival probability by days since start of study period (16 February 2020) for all homes combined, based on all-cause mortality. Shaded area designates 95% confidence intervals. Final date is 31 May 2020 (end of the study period).

What this study adds

Morbidity and mortality was high, particularly amongst residents, with the majority (91%) of resident deaths with a cause of COVID-19 or suspected COVID-19 on their death certificates dying at the homes rather than in hospital. This is not data that has been reported in other studies, so it is unclear whether this is typical or not.

The majority of confirmed cases amongst both staff and residents presented with at least one typical symptom, along with symptoms of headaches, fatigue and myalgia in around a third to a half of confirmed staff cases, highlighting the importance of considering universal staff testing rather than symptom based screening.

Outbreak peaks within each home occurred in April, at a time when only limited symptom-based testing was taking place. Universal testing did not begin until May. Overall, almost half of the residents and a quarter of the staff in this study were not tested during the outbreaks, and for those that were there was an average delay from symptom onset to test date of 20 days. RT-PCR throat swab tests are not guaranteed to produce a positive result for SARS-CoV-2 infection, with a false-negative result becoming more likely the longer the time since symptom onset,[21] and found to occur in up to 68% of pharyngeal swab tests.[22] Therefore, opportunities to confirm cases of COVID-19 may have been missed, leading to potential underestimations of disease prevalence and attack rates, with delays in implementation interventions to contain the outbreaks.

In all but one of the homes (Home A) crude attack rates were higher amongst staff than residents, which is opposite to findings of other studies.[7,9,10,13] This may be due to staff having higher risks of exposure to the virus in the community, where COVID-19 was circulating at the time.

The differences in dates of implementation of resident isolation between the homes may be an explanation for the differences in attack rates between the homes, and account for why Home A had the lowest attack rates and Home B the highest. In homes A, B and C the peak of the outbreaks occur in the days following the implementation of isolation of residents and restriction of shared spaces as an intervention measure against spread of the disease. This suggests that the majority of transmissions occurred in the days prior to this intervention, with it taking around 2 weeks to take effect and reduce the outbreak.

The delayed and lack of testing early in the outbreaks and delays in isolating residents before they became symptomatic are both likely contributing factors to the extensive transmission of COVID-19 in these homes.

Limitations of this study

There are several limitations with this study. Firstly, it is based on a single group of care homes in Wales, so whilst

representative of typical care homes in the UK, it may not be representative of other care homes that specialize in different areas of care or in other countries.

Not all staff members and residents were tested during the outbreak, so the true incidence and attack rates of COVID-19 within these study populations or a true timeline of events cannot be certain. The numbers presented for confirmed cases are almost certainly an underestimate, which is why both confirmed and possible cases were included in this study.

Genomic sequencing was only available for a portion of those residents and staff who were tested, so only limited conclusions can be drawn. Further research in this area is required to understand the true spread and transmission of COVID-19 in care homes.

Data were collected retrospectively on symptom onset dates, so may be open to recall bias. There may also be reporter bias amongst staff if they have been symptomatic as it could impact on work attendance.

Investigations into the causes of excess deaths in care homes to identify if this is due directly to COVID-19 alone, or also secondary indirect consequences of the pandemic would also be valuable.

Conclusion

These study results show that COVID-19 can spread rapidly and extensively through care homes amongst both residents and staff. All 4 co-sited homes had significant outbreaks, but it seems likely that the virus was introduced to each home on different occasions from multiple sources, rather than necessarily being spread between the homes. The high numbers of resident deaths highlight the vulnerability of this population to COVID-19.

Care homes should be enabled to take proactive steps to prevent introduction and transmission of COVID-19, including restricting visitors, universal testing and isolation of residents as required. Waiting for identification of the first case before taking action does not appear to be a sufficient strategy for preventing an outbreak.

Declarations

None.

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